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AEOLIAN SANDS ON YARKI ISLAND IN NORTHERN BAIKAL

Kozyriewa E. A., Szczypek T., Trzcinskij Ju. B. **Piaski eoliczne na wyspie Jarki na północnym Bajkale**. Wyspa Jarki stanowi bardzo wąską (50–100 m) kosę lub mierzeję, oddzielającą północny kraniec Bajkału od Angarskiego soru. Jest efektem akumulacji osadów przynoszonych przez Kiczerę i Wierchnią Angarę, a także oddziaływania fal bajkalskich. Jest więc formą holoceńską, zbudowaną z piaszczystych osadów rzecznych i jeziornych, które po wynurzeniu się nad poziom wody zaczęły być modelowane przez wiatr. Rozwinęły się tu liczne formy wydmowe o wysokości niegdyś sięgającej do 10–12 m, których podstawę stanowią dawne wały brzegowe. Praca przedstawia charakterystykę współczesnej rzeźby eolicznej tego obszaru, a przede wszystkim zwraca uwagę na mechaniczne cechy piasków przewianych na tle utworów podłoża.

Козырева Е. А., Щипек Т., Тржцинский Ю. Б. **Эоловые пески острова Ярки на северном Байкале**. Остров Ярки – очень узкий (50–100 м) бар, отделяющий северный край Байкала от Ангарского сора. Является результатом аккумуляции отложений, приносимых р. Кичерой и Верхней Ангарой, а также воздействия байкальских волн. Так, это голоценовая форма, сложена песчаными речными и озерными отложениями, которые были переработаны ветром. Здесь образовались многочисленные дюны первичной высотой до 10–12 м, основанием которых выступают давние береговые валы. В статье дано описание современного эолового рельефа территории, с учетом, в основном, механических свойств перевеваемых песков на фоне отложений субстрата.

Abstract

Yarki Island makes very narrow (50–100 m) cuspate bar or sand spit, dividing the northern part of Baikal from Angara sor. It is an effect of accumulation of deposits brought by the Kichera and Verkhnaya Angara rivers, as well as the influence of Baikal waves. Therefore it is the Holocene landform, built of sandy alluvial and lacustrine deposits, which after rising over water level became be modelled by wind. Numerous dune landforms developed here of height, which earlier reached 10–12 m, and of base made by former spill banks. The study presents the characteristics of present-day aeolian relief of this area and most of all it pays the attention to mechanical properties of blown sands against the background of substratum deposits.

INTRODUCTION

Yarki Island is the Holocene cuspate bar of 50–100 m wide, built of sandy alluvial deposits (brought by Verkhnaya Angara and Kichera; fig. 1) and lacustrine deposits, which after rising over water level became be modelled by wind. Nu-merous dune landforms of formerly height of up to 10–12 m developed here, which base was made by former spill banks (ROGOZIN, 1993). This bar

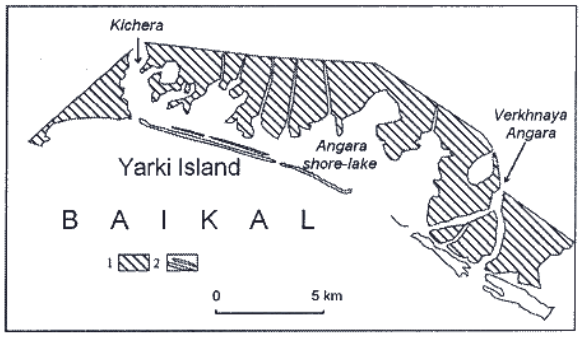

Fig. 1. Location of Yarki Island:
1 – Kichera-Angara Plain, 2 – area of bar
Rys. 1. Położenie wyspy Jarki:
1 – Równina Kiczery-Angary, 2 – obszar mierzei

already about 2000 years ago became be strongly damaged by abrasion in result of natural fluctuations of water level in Baikal (AFANASYEV, 1967; SIZIKOV, 1987), whereas since the middle of the 20th century it is additionally degraded by aeolian processes, intensified by anthropogenic factor: strong abrasion of lake waves caused by dam building on the Angara in Irkutsk and vegetation damaging by tourists (ROGOZIN, TRZCINSKY, 1993). Presently in some places during storms lake waves overflow through the island into the shore-lake–sor (after drying up this area covers – owing wind

activity – with mobile aeolian microforms – phot. 1, which disappear after the following passing of waves). These waves also caused that the eastern part of Yarki Island practically does not already exist, whereas the western part was divided into two fragments (fig. 1).

The aim of this study is a general characteristics of contemporary aeolian relief and most of all a presentation of grain size distribution and quartz grain abrasion of blown drift sands of this area against the background of deposit substratum.

Phot. 1. Thin cover of aeolian sands at the surface, over which the Baikal waves overflow into sor – the view from the lake side (phot. by E. A. Kozyreva)
Fot. 1. Cienka pokrywa piasków eolicznych na powierzchni, przez którą przelewają się fale Bajkału do soru – widok od strony jeziora (fot. E. A. Kozyriewa)

INVESTIGATION METHODS

To realise research themes the following procedures were carried out: 1) geomorphological mapping of aeolian landforms in the field, 2) sieve analysis of aeolian sands and substratum material, calculating the basic indices of grain size distribution after equations by FOLK and WARD (1957): Mz – mean grain diameter, σ – standard deviation, stating of deposits sorting, 3) research on degree of mechanical abrasion of quartz grains 1,0–0,8 mm of aeolian sands and substratum material by means of method of mechanical graniformametry by KRYGOWSKI (1964) calculating index of abrasion Wo as well as the content of grains of γ type (rounded), β (semi-rounded) and α (angular), as well as also modified microscopic method (morphoscopic) by CAILLEUX (1942) – calculating the content of grains of RM type – matted rounded, EM – rounded polished, EL – semi-rounded and NU – angular. Points of sample taking were presented in figures 5 and 6. But one should emphasise that the site 4 is not located on the island, but it reveals the analogous features: therefore it can be treated as comparative site.

CONTEMPORARY AEOLIAN RELIEF ON YARKI ISLAND

Contemporary aeolian relief on Yarki Island has decidedly deflative character, because the former dune landforms originated here undergo intensive blowing out. Simultaneously from this material small aeolian microforms are created. Of morphogenetic importance, as field observations proved, are winds blowing from two almost opposing directions: predominating – 22,6–49,6° (from the side of sor) and of minor importance – 218,2–239,6º (from the side of open Baikal; KHAK, SZCZYPEK S., SZCZYPEK T., 2006 – fig. 2).

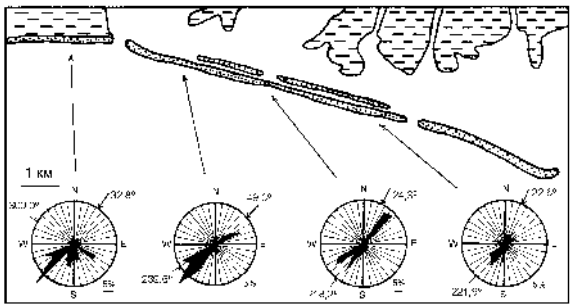

Fig. 2. Roses of azimuths of aeolian landforms axes and reconstructed mean azimuths (º) of directions of relief-forming winds on Yarki Island (after: Khak, Szczypek S., Szczypek T., 2006)
Rys. 2. Róże azymutów osi form eolicznych i zrekonstruowane średnie azymuty (º) kierunków wiatrów rzeźbotwórczych na w. Jarki (wg: Khak, Szczypek S., Szczypek T., 2006)

Actual landscape of Yarki Island within the range of aeolian relief is varied. It is possible to distinguish here – without going into details – so called low and high relief, which refer to landforms height and their morphological distinctiveness.

On Yarki Island low aeolian relief predominates. It is represented mostly by small wavy surfaces of blown out cover sands with accompanying them deflative landforms and accumulative microforms, as well as transverse dunes of height up to 1–2 m (phot. 2). They have asymmetrically shaped opposite slopes, but the slope angle is not large (8–12° : 13–21°). Leeward slopes of exposure generally towards SW are par-

tially blown out by rarely appearing winds from this direction. Whereas windward slopes of the-

Phot. 2. General view of low dunes – between the sites 1 and 2 (see fig. 5; phot. by E. A. Kozyreva)
Fot. 2. Ogólny widok wydm niskich – między stanowiskiem 1 i 2 (por. rys. 5; fot. E. A. Kozyriewa)

se landforms exposed generally towards NE are – to the rule – strongly degraded by deflation and in place of them smaller or larger deflation basins develop with appearing between them remnants of the same genesis. Similarly disturbed is the direct foreground of these slopes: deflation surfaces of different size with kept remnants also function here. Sand transported from the northern part of narrow part of the island in the majority is accumulated at the foot of leeward slopes in the form of actually developing belts of aeolian cover sands, but its part wanders towards inshore part of Baikal, causing its shallowing. In the control site 4 flat, intensively blown sandy covers predominate, therefore in the morphological landscape deflation remnants of different size are common, in shadow of which accumulation sandy shadows are created (fig. 3).

High aeolian relief on Yarki Island is significantly rarely met, but most often identified with the landscape of this area. Presently it is represented by some unusually distinct dune remnants of height up to 4–5 m, length 10–30 m and width 20–30 m. They are characterised by the presence of fragmentary, blown windward slopes and the complete lack of leeward slopes, which were disturbed by abrasion. Washed over, formerly aeolian material presently occurs at foots of steep abrasive slopes in the form of sandy piles (Wika et al., 2006). After Rogozin (1993) in the lower part of present remnants deposits of high shore embankments occur, in roof of which humus horizon is observed.

Over it only sands occur. Therefore, according to above-mentioned author, the discussed landforms are characterised by swash-aeolian genesis. Analysed remnants distinctly tower over almost flat deflation areas, on which clear indications of wa-

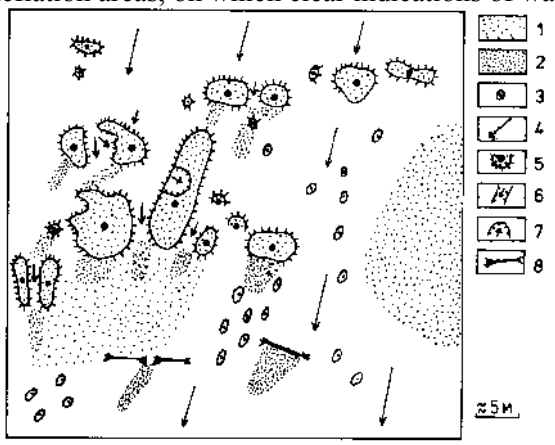

Fig. 3. Geomorphological sketch-map of compared site 4 (cf. fig. 5):
1 – aeolian cover sands, 2 – modern blowed sandy covers, 3 – sand shadows, 4 – deflation plains, 5 – deflation remnants, 6 – deflation corridors, 7 – blowouts, 8 – clogs of trees
Rys. 3. Szkic geomorfologiczny porównywanego stanowiska 4 (por. rys. 5):
1 – eoliczne piaski pokrywowe, 2 – współcześnie nawiewane pokrywy, 3 – kopczyki piaszczyste, 4 – płaszczyzny deflacyjne, 5 – ostańce deflacyjne, 6 – korytarze deflacyjne, 7 – niecki deflacyjne, 8 – kłody drzew

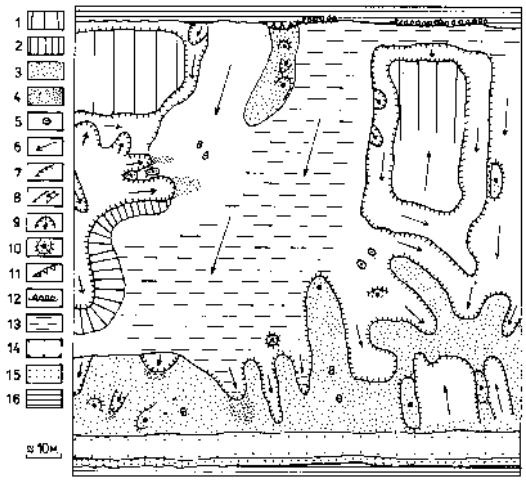

Fig. 4. Geomorphological sketch-map of fragment of high and low aeolian relief in Yarki Island near site 1 (cf. fig. 5):
1 – windward slopes of dunes, 2 – leeward slopes of dunes, 3 – aeolian cover sands, 4 – modern blowed covers, 5 – sand shadows, 6 – deflation plains, 7 – deflation undercuts, 8 – deflation corridors, 9 – blowouts, 10 – deflation remnants, 11 – abrasion undercuts, 12 – peat ridges, 13 – swampy areas, 14 – zone of "osushka", 15 – beach, 16 – water
Rys. 4. Szkic geomorfologiczny fragmentu wysokiej i niskiej rzeźby wydmowej na w. Jarki w sąsiedztwie stanowiska 1 (por. rys. 5):
1 – stoki proksymalne wydm, 2 – stoki dystalne wydm, 3 – eoliczne piaski pokrywowe, 4 – współcześnie nawiewane pokrywy, 5 – kopczyki piaszczyste, 6 – płaszczyzny deflacyjne, 7 – podcięcia deflacyjne, 8 – korytarze deflacyjne, 9

– niecki deflacyjne, 10 – ostańce deflacyjne, 11 – podcięcia abrazyjne, 12 – wały torfowe, 13 – obszary zabagnione, 14 – strefa osuszki, 15 – plaża, 16 – woda

ves overflowing are visible. Remnants are divided by more or less wide deflation corridors, on which bottom sandy covers develop. At deflation surfaces numerous sand shadows of different sizes and sometimes – shallow deflation depressions basins are also created (WIKA et al., 2006). Another example of slightly less typical high aeolian relief is demonstrated by fig. 4 as well as photos 3 and 4. High dune remnants divided by flat deflation surfaces also occur here, but – as opposed to the previous – they neighbour with sor waters, (at Baikal shore low landforms developed), whereas depression bottom is marshy and presently fixed by vegetation.

Phot. 3. Fragment of high dune relief in the neighbourhood of the site 1 (compare with fig. 5). At the foreground widespread, boggy deflation basin, at the back – blown high (up to 6 m) dune landforms (phot. by Yu. B. Trzhcinski)
Fot. 3. Fragment wysokiej rzeźby wydmowej w sąsiedztwie stanowiska 1 (por. rys. 5). Na pierwszym planie rozległa, zabagniona niecka deflacyjna, z tyłu – rozwiane wysokie (do 6 m) formy wydmowe (fot. Ju. B. Trzcinskij)

Photo 4. Blown high dune in the neighbourhood of site 1 – compare with fig. 5 (phot. by T. Szczypek)
Fot. 4. Rozwiewana wydma wysoka w sąsiedztwie stanowiska 1 – por. rys. 5 (fot. T. Szczypek)

GRAIN SIZE DISTRIBUTION OF DEPOSITS

Substratum sands

Sands of substratum deposits on the Yarki Island contain 1,5% of coarse-grained material (>0,5 mm of diameter) and 0,1% – of dusty particles of diameter of <0,1 mm. Medium-grained material (0,25–0,5 mm) decidedly predominates in them, its content amounts as much as to 94,3%. In connection with it the value of mean grain diameter Mz = 0,361 mm, and sorting degree σ = 0,27 (fig. 5 – S 1-3).

In substratum sands in control site (4) there is 1,3% of coarse material and 0,2% of dusty particles. In them also distinct predomination of average grains is visible, which content reaches 67,0%. Value of Mz = 0,285 mm, value of σ = 0,39 (fig. 5 – S4).

Aeolian sands

Drift sands on Yarki Island contain from 5,9 up to 13,5% of coarse grains (on average 11,0%) and from 0,1 up to 0,2% of dusty material (at average 0,17%). Similarly to substratum, the medium-grained deposits with contribution of 54,9–70,7% clearly prevail in them (on average 62,5%). Therefore the values of Mz fluctuate within the range 0,321–0,339 mm (on average Mz = 0,328 mm), whereas the sorting degree of deposits are determined by values of σ = 0,43–0,63 (on average σ = 0,55; fig. 5 – E1–E3).

The content of coarse-grained sand in the drift sands in the site 4 amounts to 0,8%, whereas dusty material – 0,2%. The medium-grained material predominates in the amount of 61,6%. The value of Mz = 0,276 mm, whereas the value of σ = 0,38 (fig. 5 – E4).

DEGREE OF MECHANICAL ABRASION OF DEPOSITS

Substratum sands

Results of analyses made by means of mechanical method by KRYGOWSKI (1964) indicate, that in substratum material on Yarki Island grains of α type decidedly predominate, the content of them reaches 76,6%, whereas there is 1,4% of grains

of γ type. In connection with the above-mentioned the abrasion degree Wo has the value 686 (fig. 6 – S 1-3). According to the morphoscopic method by CAILLEUX (1942) in these deposits

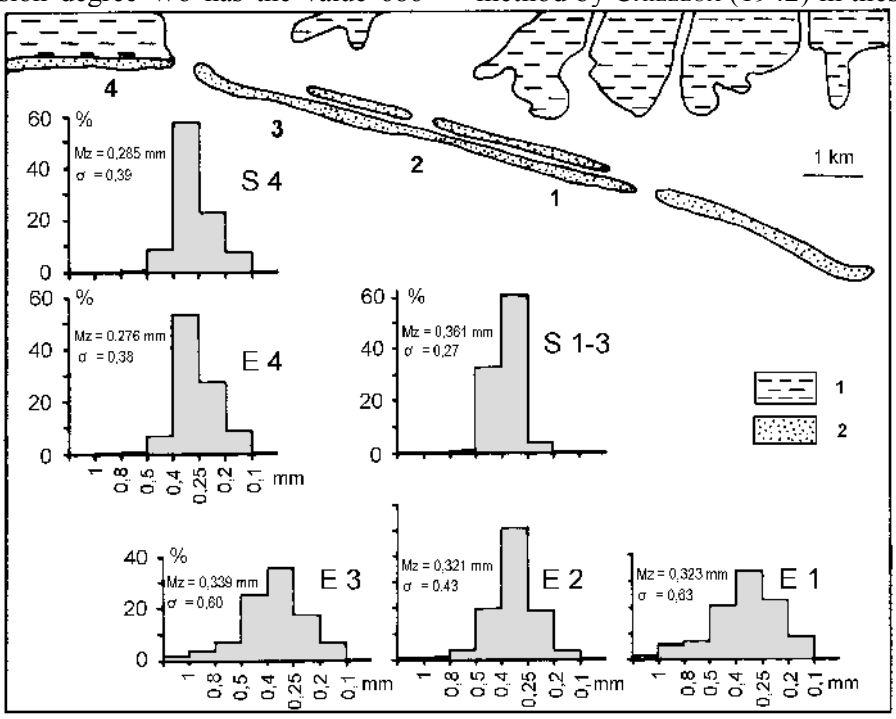

Fig. 5. Aeolian sands grain size distribution (E 1–3) of Yarki island against a background of substratum deposits (S 1–3) as well as additional site 4 (E 4/S4):
1 – marshy deposits of Kichera-Angara Plain, 2 – sandy deposits of Yarki Island and adjoining areas
Rys. 5. Uziarnienie piasków eolicznych (E 1–3) wyspy Jarki na tle utworów podłoża (S 1–3) oraz na tle dodatkowego stanowiska 4 (E4/S4):
1 – bagienne utwory Równiny Kiczery-Angary, 2 – utwory piaszczyste w. Jarki i terenów przyległych

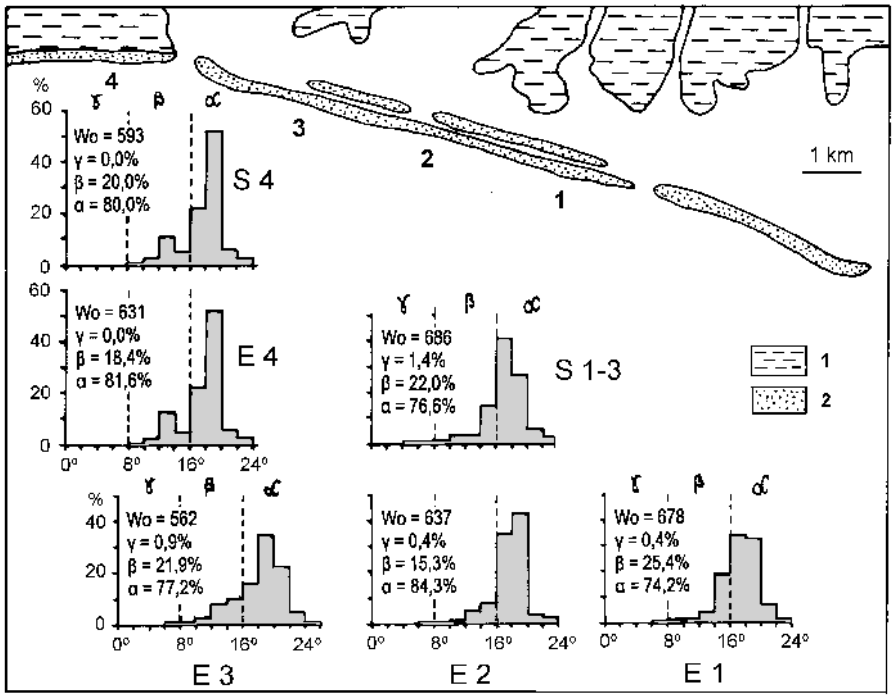

Fig. 6. Degree of mechanical abrasion of quartz grains 1,0–0,8 mm of aeolian sands (E 1–3) of Yarki Island against a background of substratum deposits (S 1–3) and additional site 4 (E 4/S4):
1 – marshy deposits of Kichera-Angara Plain, 2 – sandy deposits of Yarki Island and adjoining areas

Rys. 6. Stopień mechanicznej obróbki ziaren kwarcu 1,0–0,8 mm piasków eolicznych (E 1–3) w. Jarki na tle utworów podłoża (S 1–3) oraz na tle dodatkowego stanowiska 4 (E 4/S4); 1 – bagienne utwory Równiny Kiczery-Angary, 2 – utwory piaszczyste w. Jarki i terenów przyległych

grains of EM type predominate (95,3%), and RM grains is only 0,8%.

In the site 4 in substratum sands the largest amount is also typical for grains of α type – 80,0%, whereas γ grains are not present at all. The value of abrasion coefficient Wo amounts to 593 (fig. 6 – S 4). According to morphoscopic method grains of EM type decidedly prevail (98,5%) and there is also the lack of grains of RM type.

Aeolian sands

In drift sands of Yarki Island the contribution of grains of α type fluctuates within the range 74,2–84,3% (on average – 78,6%), and γ grains – within the range 0,4–0,9% (on average – 0,6%). The value of abrasion coefficient Wo amounts to from 562 to 678, what gives the average value – 626 (fig. 6 – E1–E3). According to morphoscopic method EM grains make 96,0–98,2% (on average 96,7%), whereas grains of RM type occur in the amount of 0,6–1,3% (on average 0,97%).

In control site 4 α grains make 81,6% of sand mass, whereas the lack of grains of γ type is noted. The value of Wo reaches 631(fig. 6 – E4). According to morphoscopic method there is 97,0% grains of EM type here, and RM grains – 0,0%.

AEOLIAN SANDS AGAINST A BACKGROUND OF SUBSTRATUM DEPOSITS

Influence of winds (NE as well as SW) on the uncovered lacustrine deposits on the Yarki Island caused the removing of the finest particles from them and leaving them in the water. The effect of it is the decidedly larger content of coarse-grained material in aeolian sands in comparison to the initial deposits. Despite of it, considering the larger amount of fine-grained material (0,1–0,25 mm), aeolian sands (13,2%) are in general finer in comparison to the source deposits (3,9%) and – simultaneously – slightly weaker sorted. The same statement refers to the control site (4), in which the given fine-granularity of blown sands is slightly less noticeable in relation to substratum, whereas it is very visible in relation to aeolian sands from the island (because substratum sands are here also clearly finer than in the island).

Aeolian sands and substratum deposits of the analysed area are characterised by low degree of mechanical abrasion, and in the case of aeolian sands it is possible to state, that they do not have almost any signs of disturbing wind influence. It is confirmed by simply symbolic content of grains of γ and RM type, as well as above-quoted values of Wo, which in the majority are lower that for parent material: there is more α grains in aeolian sands than in the substratum; it can be – as among others NOWACZYK (1986) considers – the result of easier blowing of them from the substratum. On the other hand the increase in degree of quartz grains abrasion of the discussed aeolian sands is not favoured by very small width of the island, the former as well as the contemporary (although it was some times larger).

So the clear proofs of wind influence on sandy substratum of Yarki Island and its neighbourhood are landforms shaped by this morphogenetic factor and also a certain change in granulometric composition of deposits.

REFERENCES

Afanasyev A. N., 1967: Kolebania gidrometeorologicheskogo rezhima na territorii SSSR. Nauka, Moskva: 231 p.

Cailleux A., 1942: Les actions éoliennes périglaciaires en Europe. Soc. Géol. France. Mém. Nouv. Sér., 21, 1–2, Mém., 46: 176 p.

Folk R. L., Ward W. C., 1957: Brazos river bar: a study in the significance of grain size parameters. J. Sedim. Petrol., 27, 1: 3–26.

Khak V. A., Szczypek S., Szczypek T., 2006: Napravlenia vetrov. In: Wika S., Kozyreva E. A., Trzcinsky Yu. B., Szczypek T.: Ostrova Yarki na Baikale – primer sovremennogo preobrazovania landshaftov. IZK SO RAN - Falkultet nauk o Zemle Silezskogo universiteta, Irkutsk-Sosnowiec: 36–38.

Krygowski B., 1964: Graniformametria mechaniczna. Teoria, zastosowanie. PTPN, Prace Kom. Geogr.-Geol., 2, 4. Poznań: 112 p.

Nowaczyk B., 1986: Wiek wydm, ich cechy granulometryczne i strukturalne a schemat cyrkulacji atmosferycznej w Polsce w późnym vistulianie i holocenie. Ser. Geografia, 28. UAM, Poznań: 245 p.

Rogozin A. A., 1993: Beregovaya zona Baikala i Khubsugula. Morfologia, dinamika i istoria razvitia. VO Nauka, Novosibirsk: 167 p.

Rogozin A. A., Trzcinsky Yu. B., 1993: Tekhnogennaya aktivizacia abrazionno-akkumulativnykh processov na beregakh Baikala. Geoekologia, 6: 80–85.

Sizikov A. M., 1987: Dolgoperiodicheskie izmenenia gidrologicheskogo rezhima rek Pribaikalya v golocene. V: Modelirovanie i prognozirovanie geofizicheskikh processov. Nauka, Novosibirsk: 36–39.

Wika S., Kozyreva E. A., Trzcinsky Yu. B., Szczypek T., 2006: Ostrova Yarki na Baikale – primer sovremennogo preobrazovania landshaftov. IZK SO RAN – Fa-

kultet nauk o Zemle Silezskogo universiteta, Irkutsk-Sosnowiec: 69 p.